UNPUBLISHED PRELIMINARY DATA

SEMI-ANNUAL PROGRESS REPORT OF RESEARCH PERFORMED
UNDER NASA RESEARCH GRANT NGR-17-003-003*
FOR THE PERIOD 1 AUGUST 1964 TO 31 JANUARY 1965

Submitted to:

National Aeronautics and Space Administration
Langley Research Center
Langley, Virginia

by the

Aeronautical Engineering Department
School of Engineering
Wichita State University

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Assistant Professor

*An Investigation of the Flow Fields About Delta and Double Delta Wing at Low Speeds

## SCHEDULING AND PROGRESS

Progress on the project to date is considered satisfactory. No major problems have been encountered, and no major changes in the direction of the investigation are anticipated at this time. Research to be accomplished on the project has been divided into two phases: Phase 1 (first year)--evaluation of the flow fields about a delta wing and two double-delta configurations and; Phase 2 (second year)--development and evaluation of configuration changes designed to give improved performance and stability. Details of scheduling and progress are given below.

<u>Phase I--Items accomplished during first six months</u>

August, 1964 - Planning

September, 1964-October, 1964 - Preliminary investigation of influence of wing on ground board boundary layer

November, 1964-December, 1964 - Detail design of models to be tested

December, 1964-January, 1965 - Fabrication of models and instrumentation

<u>Phase I--Items scheduled for second six months</u>

February, 1965 - Completion of models and instrumentation and preliminary calibrations

March, 1965-April, 1965 - Wind tunnel testing of models

May, 1965-July, 1965 - Data analysis, evaluation and report preparation

Phase II--August, 1965-July, 1966

Precise scheduling for this period is not possible at this time, but major tasks are listed below.

1. Analysis of Phase I results to determine most promising configuration changes (i.e., leading-edge droop, leading-edge radius, slats, fences, etc.).

2. Design and fabrication of modifications to basic wings and any additional instrumentation required.

3. Wind tunnel testing of modified configurations.

4. Data reduction, evaluation, and report preparation.

REFLECTION PLANE BOUNDARY LAYER

Early in the program it was anticipated that pressure gradients due to the wing flow field might cause low energy boundary layer air to flow from the reflection plane to the wing (or vice versa). Such flow could completely disrupt the basic vortex field and would invalidate half-model testing. In order to determine whether the reflection plane boundary layer would seriously interfere with the wing flow field, a preliminary wind tunnel investigation was conducted. A rude delta wing made from a flat plywood sheet with representative ($68^{\circ}$) sweep was tested to simulate the wing vortex-reflection plane boundary layer interaction. The wing was mounted on a simple fuselage. Force measurements were made to confirm that the wing developed lift commensurate with the generation of a strong vortex field ($C_L \approx 1.0$ @ $\alpha = 20$).

Tuft and oil streak photos show that no reflection plane boundary layer separation existed and that no appreciable transverse flow components existed.

In addition, measurements of the reflection plane boundary layer were made with velocity probes. These measurements show a boundary layer displacement thickness of 0.1 to 0.2 inches in the vicinity of the model. This is regarded as satisfactory in view of the nearly 30-inch model semi-span. Additional checks will be made with the final models to insure that adverse boundary layer interactions do not occur.

MODEL GEOMETRY

Three wing planforms have been selected for testing, in consultation with NASA officials: a simple cropped delta with $62^{\circ}$ sweep, and two double-delta wings derived from the basic delta by the addition of strakes with $75^{\circ}$ and $80^{\circ}$ sweep angles, respectively (see figures 1, 2, and 3). The basic delta has symmetric circular arc sections with 2 1/2% maximum thickness and no camber or twist. All three wings are made from aluminum and are equipped with surface static pressure instrumentation. The fuselage is a simple body of revolution, made from laminated mahogany. Wings mount 1/4 diameter below the fuselage centerline with zero incidence.

INSTRUMENTATION

Since the primary goal of this project is to obtain flow field data, emphasis has been placed upon developing a small probe capable of measuring velocity direction and magnitude at large angles of pitch and yaw. A combination probe capable of measuring pitch, yaw, and dynamic pressure is currently being evaluated and consideration is being given to the use of electrical hot-wire and hot-film type probes.

A small movable tuft grid will be used to qualitatively ascertain the streamwise vortex development over the lifting surfaces. Force and movement data will be obtained using the wind tunnel main balance system.

Consultant

Former Dean of Engineering, Kenneth Razak, was unable to serve as consultant on the project due to other commitments since his resignation as dean. Dr. Donald T. Higdon, Associate Professor of Aeronautical Engineering, is therefore serving as consultant. His resume is attached.

# RESUME

Name

Donald T. Higdon

Title

Associate Professor, Aeronautical Engineering Department

Formal Education

| | | |
|---|---|
| B.S.A.E., University of Kansas | 1955 |
| M.S.A.E., University of Kansas (NSF Fellow) | 1956 |
| Ph.D., Stanford University (Ford Foundation Fellowship) | 1964 |

(Ph.D. Thesis - "Automatic Control of Inherently Unstable Systems with Bounded Control Inputs," SUDAER Report No. 176 prepared under a grant from NSF)

Professional Experience

| | |
|---|---|
| 1954-1955 | Summer work, NACA Edwards, NACA Ames |
| 1956-1959 | Research Engineer, NASA Ames Research Center (Author of NASA Memorandum 12-29-58A). Work in airplane and structural dynamics. |
| 1959-1961 | Full-time student at Stanford on Ford Foundation Grant - course work and preliminary dissertation investigations. |
| 1961-1963 | Research Engineer at NASA Ames Research Center. Work in automatic control, engine air inlet system dynamics and control. |
| 1963 | Associate Professor, Aeronautical Engineering Department, Wichita State University |
| Sum. 1964 | Beech Aircraft Corporation, worked on missile dynamics and automatic control. |

## WING SECTION

SYMMETRIC CIRCULAR ARC
MAXIMUM THICKNESS .025 CHORD
WING AREA 6.60 SQ FT (SEMI-SPAN)
ASPECT RATIO 1.80

BASIC DELTA WING

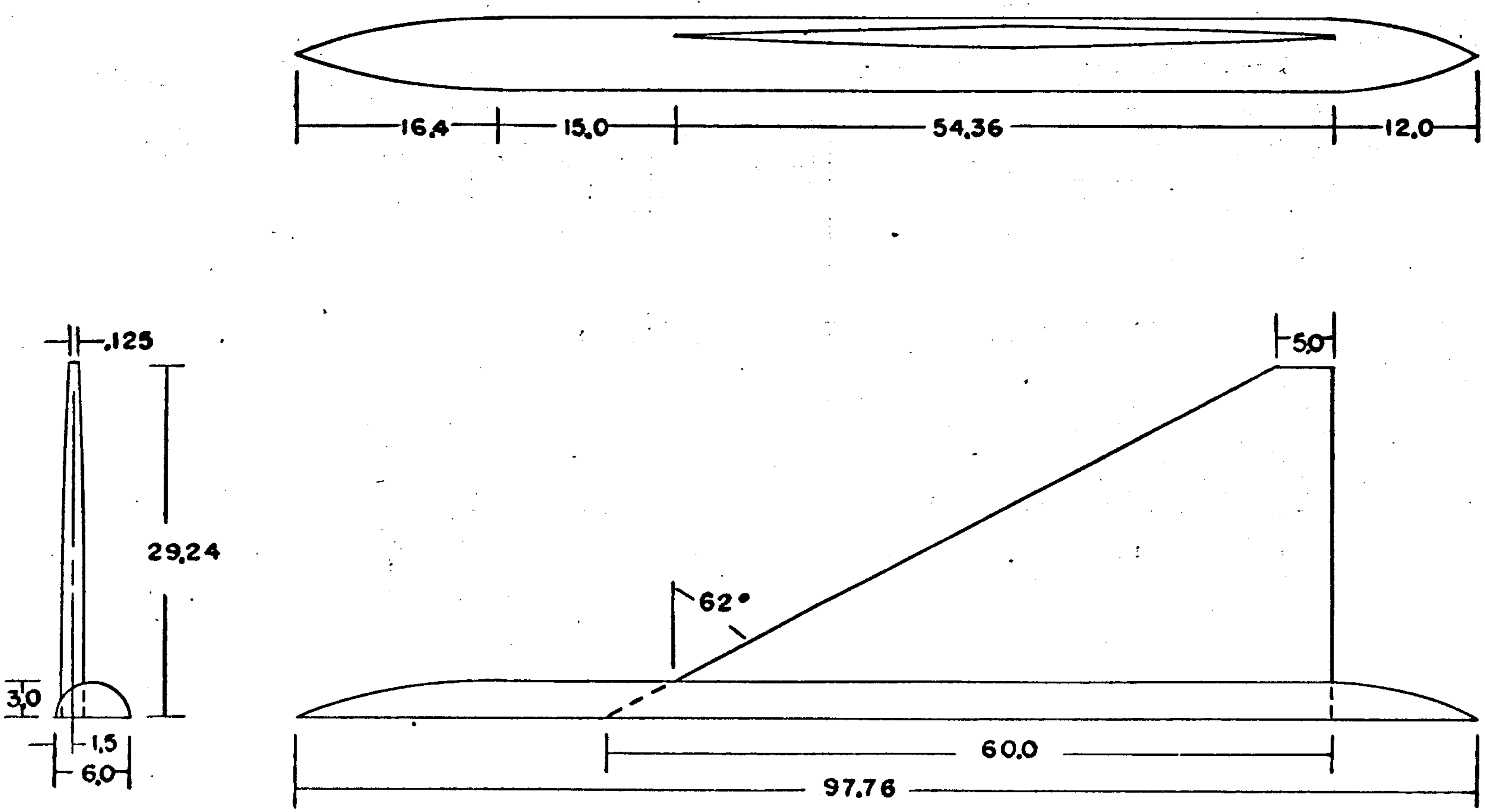


FIGURE I

WING AREA 7.39 SQ FT
ASPECT RATIO 1.61

75° STRAKE DOUBLE-DELTA

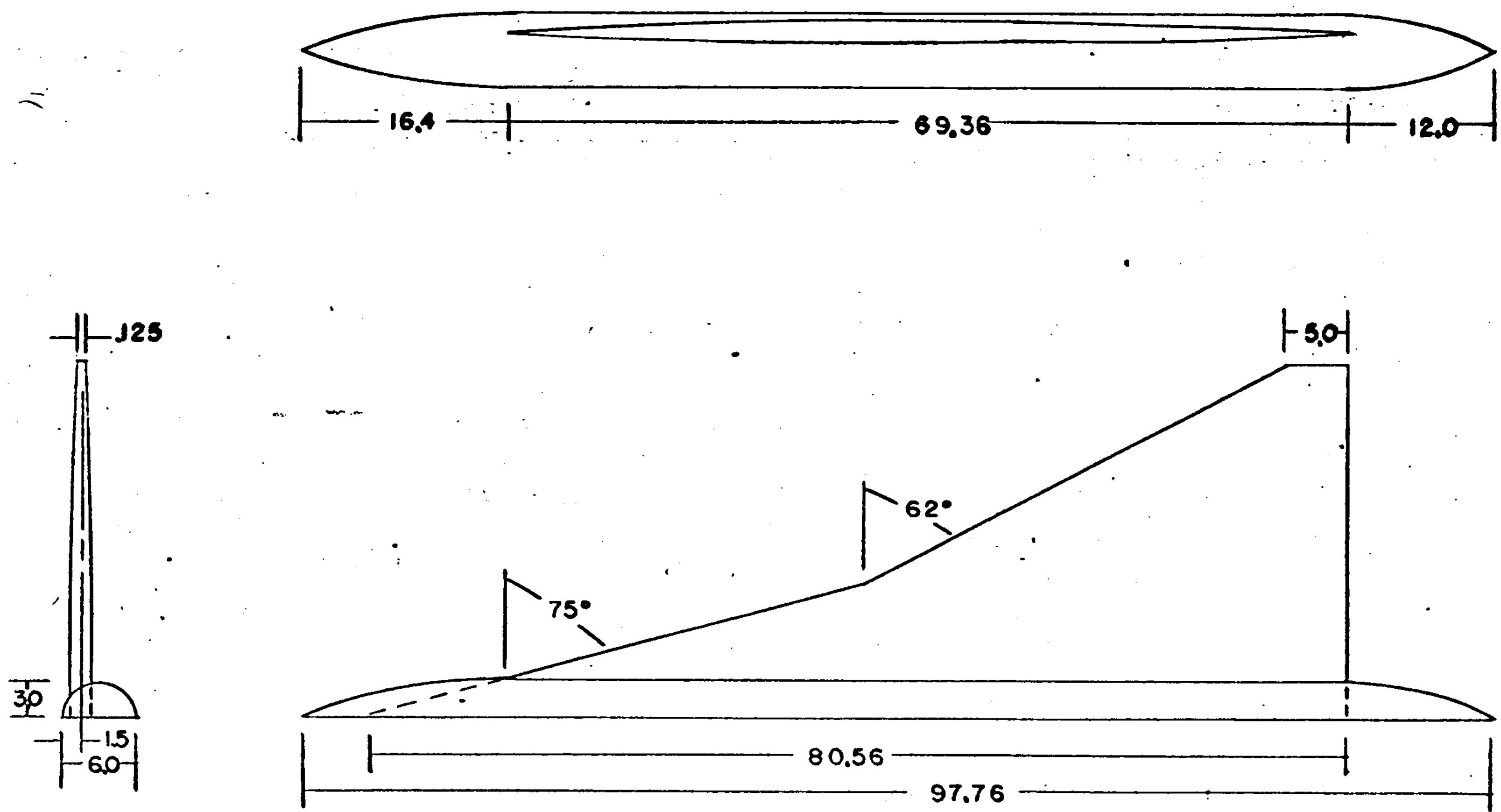


FIGURE 2

WING AREA 7.24 SQ FT
ASPECT RATIO 1.64

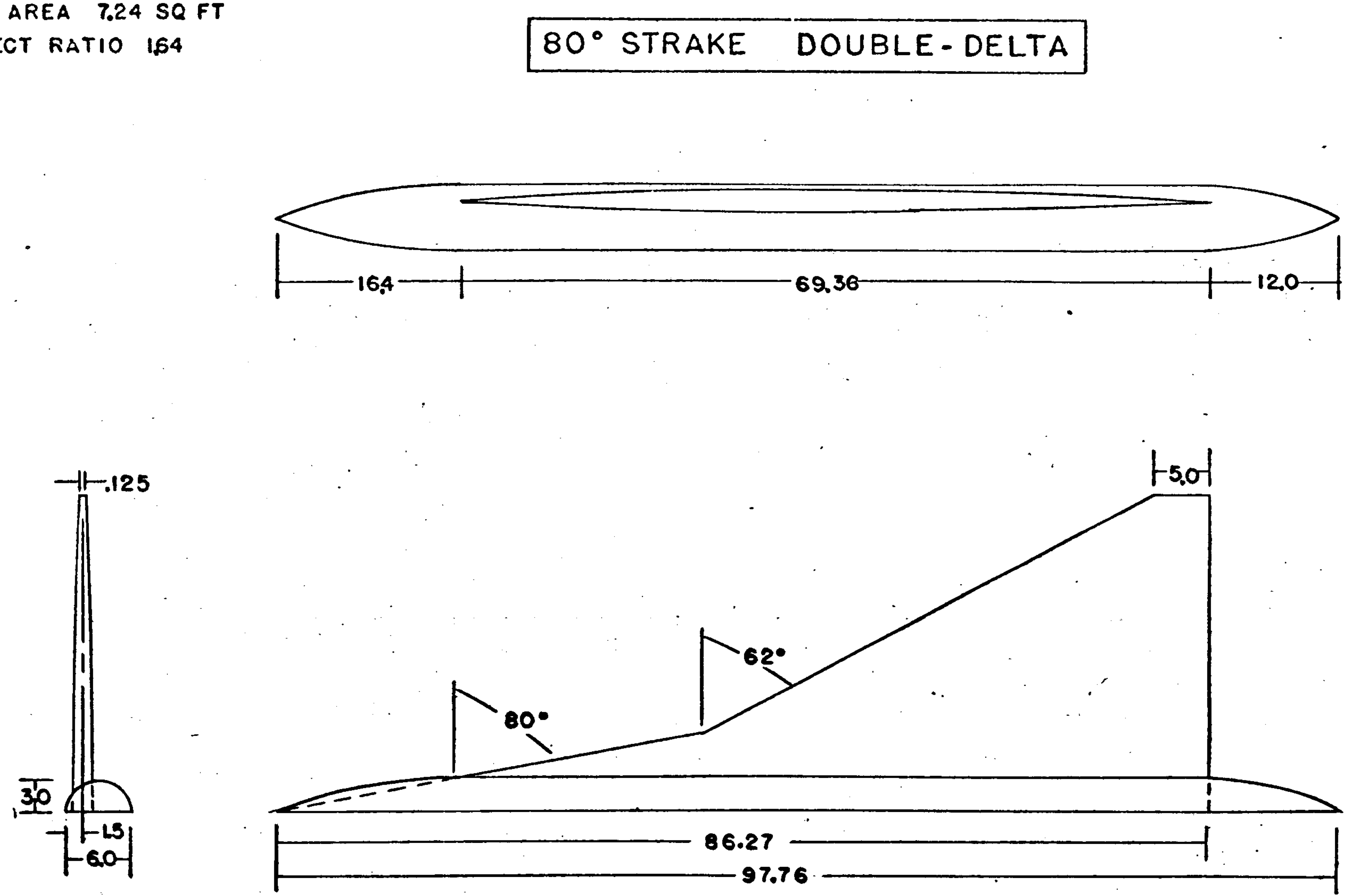


FIGURE 3